Methyl Bromide *Alternatives*

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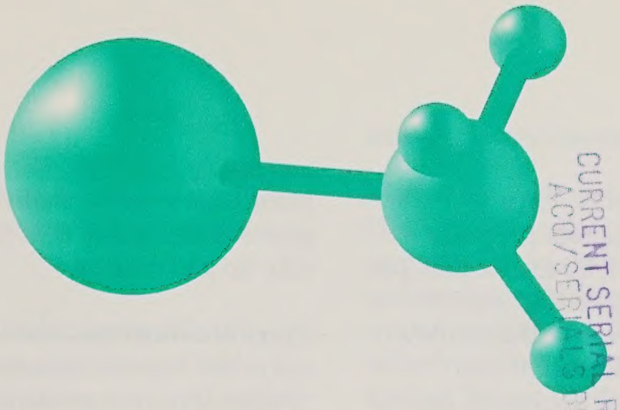

Inside This Issue

This issue and all back issues of the *Methyl Bromide Alternatives* newsletter are now available on the Internet at **<http://www.ars.usda.gov/is/np/mba/mebrhp.htm>**.
Visit the ARS methyl bromide research homepage at **<http:/www.ars.usda.gov/ismbmebrweb.htm>**.

This newsletter provides information on research for methyl bromide alternatives from USDA, universities, and industry.

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Atmospheric Impact of Agricultural Use of Methyl Bromide

To protect the earth from the detrimental effects of ozone depletion, an international treaty—The Montreal Protocol—was developed in the late 1980s. Since that time, it has been controlling the production and trade of ozone-depleting substances on a global basis and has been signed by more than 160 nations. The treaty phases out chlorofluorocarbons and other ozone-depleting compounds, including methyl bromide. In 1995, Montreal Protocol signatory countries agreed to freeze production of methyl bromide at 1991 levels for developed countries. Total phaseout for developed countries will occur January 1, 2005, except for quarantine, critical, and emergency exemptions. Developing countries will be allowed to use methyl bromide for several years past the developed-countries phaseout date.

Methyl bromide was designated an ozone-depleting substance in 1992, with an estimated ozone-depleting potential (ODP) of 0.7. The ODP is the ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11, which is designated by the Montreal Protocol to have an ODP of 1.0. ODPs for ozone-depleting substances range from 0.01 up to 10.0. For example, carbon tetrachloride and methyl chloroform have ODPs of 1.2 and 0.11, respectively. In 1998, after further study, the Montreal Protocol reduced its ODP estimate of methyl bromide to 0.4.

While research to find alternatives to methyl bromide has continued, other scientists are examining the contribution the fumigant makes in depleting the ozone layer. Methyl bromide also is liberated into the atmosphere from natural sources, and efforts are being made to determine the ratio of atmospheric methyl bromide from natural and anthropogenic (man-made) sources, specifically uses related to agriculture. This will allow a better estimate of ozone layer improvement to be expected after the phasing out of anthropogenic sources.

Of Sources and Sinks

Examination of the intricate balance between where methyl bromide comes from, where it goes, and what happens to it in the troposphere is needed, but this cycle gets complicated. "The problem with methyl bromide is that it is not entirely man-made," says James Butler, who is with the National Oceanic and Atmospheric Administration's (NOAA) Climate Monitoring and Diagnostics Laboratory. Natural sources include oceans, biomass burning, wetlands, crops, and forests.

The ocean is the largest source of methyl bromide (emitting about 56 Gg y^{-1}) and the second largest sink

(taking in about 77 Gg y^{-1}). "Gg y^{-1}" is gigagram per year, equivalent to 1,000 metric tons per year. According to research by Shari Yvon-Lewis of the NOAA Atlantic Oceanographic and Meteorological Laboratory, the ocean actually acts as a net sink, with a possible measurement range from −3,000 to −32,000 metric tons per year, meaning it takes more methyl bromide from the atmosphere than it emits to the atmosphere. However, there are many factors that influence the amount of methyl bromide emitted and absorbed by the Earth's oceans. The circulation patterns of the ocean, amount of precipitation, and water temperature all affect the delicate balance. By comparison, the contribution to the atmosphere by fumigation use of methyl bromide is reported to be about 60,000 metric tons per year, with 26,000 metric tons per year coming from soil fumigation.

The magnitude of sinks is not completely understood. "There are four ways to lose methyl bromide: removal by oceans, destruction in the stratosphere by ultraviolet radiation and OH reactions, removal by soils, and by plants," says Butler. Yvon-Lewis estimates that oceans take in 77,000 metric tons per year, as mentioned before, OH reactions and ultraviolet radiation destroy about 86,000 metric tons per year, and soils take up almost 47,000 metric tons per year. Scientists have as yet not been able to balance the equation consisting of known sources, known sinks, and measured methyl bromide in the atmosphere. "The reason the budget as we calculate it is imbalanced is because we have identified stronger sinks than we have sources. It is quite possible that we have not identified all the sources." A big unknown at this point is how much methyl bromide plants produce and how much they take up and destroy.

There are some theories about the unknown sources, namely plants. "Plants appear to produce and take in methyl bromide. There are some indications that salt marshes and other plants in the biosphere contribute to the budget," says Butler. Some research indicates that the global emission rate of the rapeseed plant is 7,000 metric tons per year. Wetlands contribute an additional 4,500 metric tons per year to the total global emission budget. Research investigating plants as sources and sinks of methyl bromide continues.

How Bad Is Methyl Bromide?

While the lowered ODP rate may seem encouraging, methyl bromide does more damage in the ozone layer than most other ODP substances, partly because of the high mixing rate in the atmosphere. It also escapes easily into the atmosphere where it contributes to the depletion of the ozone layer. Bill Thomas, of the U.S. Environmental Protection Agency, states, "While methyl bromide's ODP has fallen, it is unlikely it will fall below the 0.2 threshold. But if it did, it would be reclassified as a Class II substance, only altering the phaseout time line—not eliminating it." The present best guess is that emissions of methyl bromide from agricultural uses account for 20 to 30 percent of global methyl bromide sources and are thought to be responsible for 3 to 10 percent of the stratospheric ozone depletion, according to NOAA researchers.

Peach Replant Disorder

Peach replant disorder is a nebulous problem that occurs when young trees are planted into old orchard soil. Nematodes, *Phytophthora* spp., and other soil pests may be abundant in the old orchard soil and attack the young root system of newly planted trees. Resulting symptoms, such as poor growth and nutritional deficiencies, are unevenly distributed across the field. Because methyl bromide is such an effective biocide, it easily controlled replant disorder even though the specific causes in a given orchard were not identified.

Replant disorder plagues other crops as well, including grapevines and other fruit trees. Nationwide there are 4.4 million acres of orchards and vineyards, with California having a little less than half of this. In the past, the soil would be fumigated with 300–400 lb/acre of methyl bromide before the young trees were planted. That is no longer feasible due to the rising cost of methyl bromide. Import and manufacture of methyl bromide in 2001 is limited to 50 percent of the amount used in 1991. The result has been an increase in the cost from $1.00/lb a couple of years ago to approximately $3.50/lb now. "Methyl bromide is basically no longer an option for perennial growers," said Thomas Trout, an ARS agricultural engineer in Fresno, California. "Most growers can't afford the $1,800 per acre it costs to apply methyl bromide."

Due to the phaseout of the fumigant, researchers are now focusing on what causes replant disorder and what the best alternatives for controlling the disorder might be.

Just What Is Peach Replant Disorder?

Peach replant disorder is an ill-defined disease complex that causes stunting of newly planted peach trees in nonfumigated orchard soil previously planted to peaches. It also affects other crops that use peach rootstock, including almond. "Mature trees seem to develop resistance, but when a young tree is planted in the same soil, it doesn't perform well," explains Trout. According to Greg Browne, ARS research plant pathologist at Davis, California, there is much to learn about the problem. The soil harbors a complex mix of organisms that may contribute to replant disorder. He says, "some replant disorder culprits are well documented, including several parasitic nematode species, oak root fungus, and *Phytophthora,* while much less is known about possible roles of other suspects. Even in the absence of the well-documented causes, replant disorder can occur." Browne's lab is investigating possible roles of many microbes collected from peach and almond replant disorder sites.

"In the past," relates ARS research plant pathologist Sally Schneider, "because methyl bromide has such a wide spectrum of activity, scientists didn't need to know the specific cause of replant disorder in a given orchard." That is no longer the case. "Potential alternatives sometimes are effective against only one pathogen group, such as fungi or nematodes, rather than the broad spectrum of pests and pathogens controlled by methyl bromide." Schneider also says, "better diagnoses of what is causing replant disorder in a particular orchard are needed in order to select the management alternatives that are best able to control the pests and pathogens actually present in a given orchard."

Methyl bromide is capable of killing most life stages of soil-dwelling organisms as well as the roots of old trees and vines. Without fumigation, some old roots are likely to remain alive for at least 3 years after tree removal. These woody roots continue to provide a food source for a variety of soil-borne nematodes, insects, and plant pathogens. These pests and pathogens can then attack and damage the root systems of the newly planted trees.

What To Do?

Trout and Husein Ajwa, an ARS soil scientist, investigated fumigation and fallowing effects on replant disorder on peaches at the USDA-ARS research facility in Parlier, California. The researchers tracked tree growth and the level of nematode populations in the replanted orchard following treatment with various fumigants and fallow periods of up to 3 years. Pin nematodes predominated in the plots, with very few other plant parasitic nematode species found. Although pin nematodes are not commonly considered important plant parasites, their population levels are used as indicators of treatment effectiveness.

Fallowing resulted in reduced pin nematode populations and improved tree growth, dramatically reducing the populations of pin nematodes, especially after 2 and 3 years. All nematodes found after 3 years of fallow were more than 3 feet deep in the soil. Each additional fallow year in the study resulted in improved tree growth, but even a 3-year fallow was not as effective as methyl bromide.

Methyl bromide and 1,3-D (Telone) were used as soil fumigants to control nematodes, and no nematodes were detected in plots treated with either chemical. Plant growth in plots treated with drip-applied Telone C-35 (InLine) was better than growth in the no-fallow check plots and as good as plant growth in plots treated with methyl bromide. An interesting result in one of the studies was that the best first-year growth was in plots drip-fumigated with chloropicrin. Chloropicrin is not considered a good stand-alone nematicide, but is a good fungicide. This result suggests that there are important aspects of the peach replant problem that are fungal in nature. Trout's study will continue through at least 4 years to quantify the effects on tree productivity by measuring fruit yield and quality.

For Future Consideration

Methyl iodide, or iodomethane, is a promising chemical fumigant that is currently in the registration process. In field trials conducted at the Parlier facility by Cynthia Eayre, an ARS research plant pathologist, iodomethane was as effective as methyl bromide in its ability to control peach replant disorder. "Iodomethane is applied using the same equipment as methyl bromide, provides the same control, but is more flexible because it is a liquid at ambient temperature instead of a gas, like methyl bromide. This means we can apply it through drip lines in addition to shank-injected applications," said Schneider. The registrant is planning to have iodomethane approved for use by 2004.

For now, Telone will probably be the most widely used option. Though fallow periods provided some relief from replant disorder, it is not a realistic option for most

growers. The cost of leaving an orchard fallow for 2 to 3 years is too high to be economically acceptable. "A switch to Telone by perennial growers will begin this fall due to the high cost of methyl bromide," asserts Trout.

Technical Reports

WEED CONTROL OPTIONS IN CALIFORNIA STRAWBERRY WITHOUT METHYL BROMIDE

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Introduction

Strawberry production in California is a two-component system consisting of nursery and fruit production, and methyl bromide has been used as the basis for weed control for both components. The phase-out of methyl bromide requires the development of alternative fumigant systems for both nursery and fruit production systems. Alternative fumigants in evaluation include chloropicrin alone, iodomethane plus chloropicrin mixture 50:50, 1,3-D plus chloropicrin mixture 65:35, and metam sodium. Iodomethane was evaluated in nurseries, and several emulsified fumigants were evaluated in a fruiting field. The objective of the work reported here was to evaluate the weed control efficacy of alternative fumigants in both nursery and fruiting fields.

Methods

Iodomethane evaluation in nursery production. The weed control efficacy of iodomethane was compared to methyl bromide in the spring and summer of 2000 at a low elevation nursery at Ballico, CA and a high elevation nursery at Susanville, CA. The effects of iodomethane on weed seed viability, weed densities and time required to hand weed were measured. Iodomethane was applied as a 50:50 mixture with chloropicrin (IM/Pic) at the rate of 350 lbs. per acre (lb./A). Methyl bromide and chloropicrin (MeBr/Pic) was applied for comparison as a 57:43 mixture at the rate of 400 lb./A at Ballico and 355 lb./A at Susanville. Each treatment was replicated four times and the plot size was 2860 ft^2.

The effect of fumigants on weed seed was tested by burying nylon mesh bags containing seed of common purslane (*Portulaca oleracea*), prostrate knotweed (*Polygonum aviculare*) and little mallow (*Malva parviflora*) prior to fumigation. Following fumigation, bags were retrieved and the percentage viable seed was determined using tetrazolium salts.

Emulsified fumigant evaluation in fruiting fields. Evaluation of emulsified fumigants was initiated in November 1999 in a fruit production field near Salinas, CA. Four weeks after fumigation, the mulch was removed and cultivar 'Selva' was planted in two rows at 12-inch spacing between plants. Emulsified fumigants were applied through two drip lines placed 8 inches apart in the middle of the bed. Drip-applied treatments were: 1,3-D plus chloropicrin mixture in an emulsified formulation (1,3-D + Pic EC) at 253 and 422 lb./A, metam sodium at 213 and 320 lb./A, chloropicrin alone (Pic EC) at 328 lb./A, 1,3-D + Pic EC followed by (fb) metam sodium at 253 lb./A fb 213 lb./A, and 422 lb./A fb 320 lb./A, and Pic EC fb metam sodium at 328 lb./A fb 213 lb./A. Bed shank-applied materials were methyl bromide plus chloropicrin 67:33 (MeBr/Pic) at 400 lb./A, 1,3-D plus chloropicrin mixture 65:35 (1,3-D + Pic) at 410 lb./A and chloropicrin alone (Pic) at 300 lb./A. Each treatment was replicated three times and the plot size was three 52-inch beds wide by 100 ft. long.

The effect of emulsified fumigants on the native weed biomass was measured on February 24, 2000 by harvesting the weeds present on the center bed of each plot (250 ft^2). Weeds were identified by species and then biomass was determined. Weed seed bags containing common purslane, little mallow, and prostrate knotweed were placed in nylon mesh bags and buried in all plots prior to fumigation (data not shown).

Results

Iodomethane evaluation in nursery production. Percentage viable common purslane and prostrate knotweed seed was much lower for seed treated with IM/Pic or MeBr/Pic compared to untreated seeds at both sites (Table 1). Differences in percentage viable seed were not found between IM/Pic and MeBr/Pic treatments for common purslane or prostrate knotweed. At Susanville, percentage viable was lower for little mallow seed exposed to MeBr/Pic compared to untreated seed; however a 77.1 percent viable seed is not considered an acceptable level of control. A difference in little mallow seed viability was not observed at Ballico.

The effect of fumigants on emergence of native weed populations was evaluated by periodically determining the density of each

weed species. Common lambsquarters (*Chenopodium album*) and little mallow were the most abundant weeds at Susanville (Table 2). Problem weeds at Ballico were carpetweed (*Mollugo verticillata*) prostrate spurge (*Euphorbia humistrata*) and filaree (*Erodium* spp.). Both IM/Pic and MeBr/Pic reduced the number of common lambsquarters, carpetweed and prostrate spurge for each date. MeBr/Pic reduced the number of filaree compared to IM/Pic for the first sample date, but differences were not found for the second count. The number of little mallow was lower in the MeBr/Pic treated plots compared to controls for the first weed count at Susanville; for other weed counts, there was not a difference.

Less time was required to hand weed plots treated with MeBr/Pic or IM/Pic at Ballico compared to untreated areas (Table 3). A difference was not found between MeBr/Pic and IM/Pic.

These results suggest that the weed control efficacy of IM/Pic 50:50 at 350 lb./A was approximately equal to MeBr/Pic 57:43 at 355 to 400 lb./A.

Emulsified fumigant evaluation in fruiting fields. All fumigant treatments significantly reduced common chickweed (*Stellaria media*) and shepherdspurse (*Capsella bursa-pastoris*) biomasses compared to the untreated check (Table 4). Bur clover (*Medicago polymorpha*) and little mallow biomass was greater in the MeBr/Pic treatment than in the untreated check. This was likely due to the germination stimulus on bur clover and little mallow seed provided by MeBr/Pic. Results indicate that drip-applied 1,3-D + Pic EC provided better control of bur clover and little mallow than shank-applied 1,3-D + Pic. Similarly, drip-applied Pic EC provided better control of bur clover and little mallow than shank-applied Pic. The weed control provided by drip-applied 1,3-D + Pic EC at 253 or 422 lb./A was not improved by the addition of a sequential application of metam sodium at 213 or 320 lb./A, respectively. Similarly, the weed control provided by drip-applied Pic EC was not improved by a sequential application of metam sodium at 213 lb./A. Metam sodium alone at 213 or 320 lb./A provided poor to fair control of all species.

Sequential applications of metam sodium did not improve the weed control provided by drip-applied 1,3-D + Pic EC or Pic EC.

Table 1. The effect of iodomethane (IM) or methyl bromide (MeBr) in combination with chloropicrin (Pic) on common purslane, prostrate knotweed and little mallow seed viability. Results are from two field studies: Susanville high elevation and Ballico low elevation strawberry nurseries.

Fumigant	Rate (lb./A)	% viable seed: Common purslane	Prostrate knotweed	Little mallow
		Susanville (high elevation)		
IM/Pic 50:50	350	0.1 b	9.2 b	79.0 ab
MeBr/Pic 67:33	355	0.3 b	0.5 b	77.1 b
Untreated	0	84.9 a	84.1 a	83.9 a
LSD		24.5	26.8	5.3
		Ballico (low elevation)		
		Common purslane	Prostrate knotweed	Little mallow
MeI/Pic 50:50	350	0.0 b	0.0 b	75.2 a
MeBr/Pic 57:43	400	0.0 b	0.0 b	76.5 a
Untreated	0	78.7 a	80.3 a	71.3 a
LSD		27.8	27.8	9.1

Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 2. The effect of IM/Pic and MeBr/Pic on native weed emergence at Susanville and Ballico strawberry nurseries. Weeds were counted on three occasions (17 May, 20 June and 3 Aug.) at Susanville, and on two occasions (15 June and 18 July) at Ballico.

Fumigant	Rate (lb./A)	Number of weeds per m^2					
		Susanville (high elevation)					
		Common lambsquarters			Little mallow		
		17 May	20 June	3 Aug.	17 May	20 June	3 Aug.
IM/Pic 50:50	350	37.6 b	5.6 b	2.4 b	5.2 ab	16.4 a	18.4 a
MeBr/Pic 67:33	355	5.2 b	1.2 b	0.0 b	1.2 b	19.6 a	10.0 a
Untreated	0	129.2 a	64.4 a	18.8 a	22.4 a	26.0 a	12.8 a
LSD		82.4	51.2	14.8	18.0	23.6	18.0
		Ballico (low elevation)					
		Carpetweed		Prostrate spurge		Filaree	
		15 June	18 July	15 June	18 July	15 June	18 July
IM/Pic 50:50	350	0.0 b	0.0 b	2.4 b	21.6 b	23.6 a	1.6 a
MeBr/Pic 57:43	400	0.0 b	0.0 b	0.4 b	11.6 b	9.2 b	3.6 a
Untreated	0	37.6 a	105.6 a	23.6 a	255.2 a	20.4 ab	1.2 a
LSD		28.0	7.8	10.0	109.6	13.6	2.7

Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 3. The amount of time (hrs/A) required to hand-weed following fumigation at Ballico

Fumigant	Rate (lb./A)	Time required to hand-weed (hrs/A)
	Ballico (low elevation)	
MeI/Pic50:50	350	57.7 b
MeBr/Pic57:43	400	45.7 b
Untreated	0	93.2 a
LSD		12.9

Means followed by the same letter do not significantly differ (P=0.05, LSD).

Table 4. Weed biomass and percentage weed control provided by shank-applied methyl bromide plus chloropicrin 67:33 (MeBr/Pic), 1,3-D plus chloropicrin mixture 65:35 (1,3-D + Pic), and chloropicrin alone (Pic) and drip-applied 1,3-D plus chloropicrin mixture 65:35 in a emulsifiable formulation (1,3-D + Pic EC), chloropicrin emulsifiable formulation (Pic EC) and metam sodium. Sequential treatments of 1,3-D + Pic EC or Pic EC followed by metam sodium were also tested. Weed biomasses (g) were determined by harvesting all weeds in the center bed of each plot (250 ft^2), weeds were then identified by species and weighed. Dominant species present were bur clover, common chickweed and little mallow. The total weed biomass includes bur clover, common chickweed, common groundsel, little mallow, shepherdspurse and yellow rocket.

Fumigant [a]	Rate	Method	Bur clover		Chickweed		Little mallow		Shepherdspurse		Total weeds	
	lb./A		biomass	%	biomass	%	biomass	%	biomass	%	biomass	%
Untreated	—	—	1405 de	0	10707 a	0	78 abc	0	3186 a	0	17367 a	0
MeBr/Pic 67:33	400	Shank	3922 a	-177	169 b	98	325 abc	-317	53 c	98	4567 bc	74
1,3-D + Pic	410	Shank	3291 abc	-134	147 b	99	287 abc	-268	69 c	98	3969 bc	77
1,3-D + Pic EC	253	Drip	1814 de	-29	228 b	98	356 a	-356	73 c	98	2757 bc	84
1,3-D + Pic EC	422	Drip	1413 de	-1	169 b	98	37 abc	52	15 c	100	1670 c	90
Pic	300	Shank	3561 ab	-154	1106 b	90	164 abc	-110	497 c	84	5745 bc	67
Pic EC	328	Drip	838 e	40	365 b	97	22 bc	72	150 c	95	1772 c	90
Metam sodium	213	Drip	1909 de	-36	3551 b	67	127 abc	-62	669 bc	79	7497 b	57
Metam sodium	320	Drip	1453 de	-3	1872 b	83	103 abc	-32	1306 b	59	7186 b	59
1,3-D + Pic EC fb metam sodium	253 fb 213	Drip	2127 cde	-51	827 b	92	17 bc	78	122 c	96	3205 bc	82
1,3-D + Pic EC fb metam sodium	422 fb 320	Drip	1274 de	9	51	100	29 abc	63	19 c	99	1450 c	92
Pic EC fb metam sodium	328 fb 213	Drip	1469 de	-5	362 b	97	51 abc	35	50 c	98	1912 c	89
LSD 0.05			1353		3571		332		773		4936	

[a] 1,3-D + Pic EC mixture or Pic EC alone was applied followed by (fb) a metam sodium treatment 5 days later, i.e., metam sodium was applied as a sequential treatment.

Means followed by the same letter do not significantly differ (P=0.05, LSD)

ALTERNATIVES FOR VINEYARD REPLANT AND GRAPEVINE NURSERIES

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"Replant disorder" is a general term for the decline in vigor in a newly replanted vineyard as compared to vines planted in "non-vineyard" soil. There can be various factors contributing to replant disorder, which undoubtedly vary among sites. The current practice for replanting grapes into a vineyard with a known soilborne pest problem is to fumigate with either methyl bromide or 1,3-dichloropropene (1,3-D). Importation and manufacture of methyl bromide will be phased out by 2005 in compliance with the U.S. Clean Air Act and the Montreal Protocol. Use of 1,3-D, or Telone, is limited in California by township caps. Our search for alternative treatments includes new application methods for currently registered compounds, unregistered materials, plant resistance, and cultural practices.

An existing "Thompson Seedless" vineyard, located at the USDA Parlier, CA, research station was selected for a grape replant field trial. The treatments are described in Table 1. Each plot was 3 rows wide and 7 vines long and replicated 5 times in a randomized complete block design. Telone/vapam treatments were applied in early January, 1998. Methyl bromide and methyl iodide treatments were applied in late April, 1998. In July of 1998, each plot was planted with three grape variety/rootstock combinations; own-rooted Thompson Seedless, Merlot on Harmony rootstock, and Merlot on Teleki 5C rootstock. The rootstocks vary in levels of resistance to nematodes, which are thought to play a role in replant disorder. First year results of this study were reported at last year's Methyl Bromide Conference. This paper reports data from the 2nd year of this trial.

Soil samples were collected to a depth of 24 inches in May 1999, October, 1999, and April, 2000. There were no detectable plant parasitic nematodes in any of the plots treated with methyl bromide (MB), methyl iodide (MI), or the telone/vapam (T/V) combinations until April 2000, and then only at extremely low levels (Table 2). Nematode populations for the rest of the treatments are given in Table 2. The telone/vapam combinations and methyl iodide have controlled the nematode populations as well as methyl bromide to date. The 18 month fallow treatments reduced the number of rootknot nematodes detected in May 1999. This advantage was not detected in the Fall, 1999 sampling, but was again present in Spring, 2000 samples from Thompson Seedless vines. An 18 month fallow results in a loss of use (and income) of the vineyard for an additional year, but also removes the actively growing vine and upper roots as biological factors in the ecosystem for that year. The use of rootknot resistant rootstocks reduced the population level of rootknot, but not citrus, nematodes. Resistant rootstocks can be effective, but are more expensive than own-rooted vines and often not resistant to the diversity of pests that is encountered in a replant situation.

In February, 2000, caliper measurements of the vine trunk were made. Thompson seedless vines were larger in MB than in the untreated, 18 month fallow (18F), 18F+Cover Crop (18F+CC), and MI plots. Vines in the T/V combinations were intermediate in size, not significantly different from either group. Merlot/Teleki vines were larger in the untreated plots than in the 18F, MB, or MI. The Merlot/Harmony vines were significantly larger in the MB and T/V combinations than in the 18F+CC plots. Data on plant growth and nematode populations will be collected for at least five years in order to determine the impact of the treatments not only on vegetative plant growth, but also on fruit yield and quality. Our first evaluation of fruit yield and quality will occur this fall.

Nursery Study. Soil fumigation with methyl bromide has commonly been used prior to planting grapevine field nurseries to meet the requirements of the California Department of Food and Agriculture's (CDFA) Nursery Stock Nematode Control Program. Growers of perennial nursery crops will need an alternative to methyl bromide in order to continue to produce clean planting material and meet CDFA's requirements following the ban on methyl bromide.

In the spring of 2000, a grape nursery study was initiated. No field sites with existing plant parasitic nematode populations were available, so muslin bags filled with soil containing rootknot and citrus nematodes were buried in a previously fumigated field at the USDA research station in Parlier, CA. Bags were buried at depths of 1, 3, and 5 feet. Plots were set out in a randomized complete block design with 4 replications per treatment. The treatments were:

- untreated control
- methyl bromide at 400 lbs

acre (treated control), tarped
- shanked methyl iodide (200 lbs/acre)+chloropicrin (200 lbs/acre), tarped
- drip applied Telone II EC (44 gal./acre or 390 lbs/acre of 1,3-D), tarped
- drip applied methyl iodide (200 lbs/acre)+chloropicrin (200 lbs/acre), tarped
- drip applied methyl iodide (100 lbs/acre)+chloropicrin (100 lbs/acre), tarped
- drip applied propargyl bromide (100 lbs/acre), tarped
- drip applied propargyl bromide (200 lbs/acre), tarped

Drip tapes were laid on the top of the plant bed and beds were covered with plastic prior to application of the materials. All dripped applied treatments were applied in 3 inches of water over a 9-hour period.

Nematode Control. The nematode bags were recovered 2 weeks after treatment. Soil was placed on baermann funnels to recover only live nematodes. No live nematodes were recovered at any depth in the shanked treatments. All dripped treatments gave excellent control at the 1 ft. depth. At the 3 ft. level, fewer than 5 nematodes were recovered in the high rate of propargyl bromide and both rates of methyl iodide/chloropicrin compared to 160 nematodes in the untreated control. Effective control at the 5 ft. level was achieved only with the low and high rates of methyl iodide/ chloropicrin. The soil was fairly dry when the treatment began, and it is likely that the 3 inches of water was insufficient to move the other materials down to the 5 ft. level. Further tests will be conducted to determine if control at the 5 ft depth improves when materials are applied in greater volumes of water.

Phytotoxicity. Canes of Cabernet Sauvignon and Freedom were planted at weekly intervals beginning one week after treatment and continuing for 4 weeks. Number of actively growing vines was recorded approximately 2 months after treatment. There were no significant differences between the percent live vines of Cabernet in shank fumigated plots and untreated controls at any planting date. Freedom vines planted 3 weeks after treatment in plots treated with shank applied methyl iodide/chloropicrin, had significantly fewer live vines than the untreated control or methyl bromide fumigated plots. There were no significant differences between Freedom vines in the untreated control and shank fumigated plots at any other planting date. There were fewer live Cabernet vines in the telone and high rate of propargyl bromide plots planted one week after treatment compared to the methyl bromide and untreated control plots. Freedom suffered more phytotoxicity when planted one week after treatment in the low rate of dripped methyl iodide/ chloropicrin and the high rate of propargyl bromide than in the untreated control or methyl bromide plots. There were no significant differences in percent live vines among dripped treatments and the untreated control and methyl bromide plots for either grape variety for plots planted 2, 3 or 4 weeks after treatment. Quality and marketability of the vines will be evaluated at harvest this winter in accordance with standard nursery practices.

Weed Control. Approximately seven weeks after planting, weeds were removed from a one ft. wide swath on each side of the plant row. Weeds were air-dried for 2 weeks and weighed. All treatments except the low rate of methyl iodide/chloropicrin had significantly fewer weeds than the untreated control and were not different from the control achieved with methyl bromide.

This study will be repeated next year at a field site with existing populations of plant parasitic nematodes.

Table 1. Treatments applied to a "Thompson Seedless" replant field.

Treatment 1 - untreated control

Treatment 2 - 18 month fallow

Treatment 3 - 18 month fallow plus a sorghum-sudangrass hybrid cover crop

Treatment 4 - a shanked application of methyl bromide (400 lbs/acre = 28 gal/acre), tarped (the treated control)

Treatment 5 - a shanked application of methyl iodide (400 lbs/acre = 21 gal/acre), tarped

Treatment 6 - combination application of Telone II EC (35 gal/acre or 310 lbs/acre of 1,3-D) in 60 mm water through a buried drip tape plus Vapam (26 gal/acre of 42% metam sodium) through microsprinklers

Treatment 7 - same as #6 except the Telone was applied in 100 mm of water;

Treatment 8 - same as #6, but with an 18 month fallow

Treatment 9 - same as #7 but with an 18 month fallow

Table 2. Nematode populations per 150 cc soil sampled May 1999, October 1999, and April 2000 in the grape replant trial, mean of 5 replications. Means for each nematode genus/rootstock combination followed by the same letter are not significantly different at the *P* = .05 level.

Treatment	Thompson Seedless - own rooted														
	Meloidogyne sp.			*Criconemella sp.*			*Tylenchulus sp.*			*Xiphinema sp.*			*Paratylenchus sp.*		
	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00
Untreated Control	126.0a	374.0a	475.2a	9.2a	0.8b	1.8a	225.6a	302.0a	1416.0a	3.2a	9.2a	8.4a	34.0a	3.0a	0.0b
18 Month Fallow	62.4b	304.0a	278.4b	6.8ab	2.4b	6.6a	293.2a	282.0a	840.0b	0.8a	5.6ab	4.2ab	23.6a	8.0a	0.0b
18 Month Fallow plus cover crop	36.4bc	235.0ab	146.4bc	8.4a	7.2a	3.6a	268.0a	288.0a	628.8bc	2.4a	4.8ab	4.8ab	15.2a	2.0a	2.4a
Methyl Bromide (400 lbs/acre	)0.0c	0.0b	0.0c	0.0b	0.0b	0.0a	0.0b	0.0b	1.2c	0.0a	0.0b	0.0b	0.0a	0.0a	0.0b
Methyl Iodide (400 lbs/acre)	0.0c	0.0b	3.0c	0.0b	0.0b	0.0a	0.0b	0.0b	0.0c	0.0a	0.0b	0.0b	0.0a	0.0a	0.6b
Telone II EC (in 60mm water) +Vapam	0.0c	0.0b	0.0c	0.0b	0.0b	0.0a	0.0b	0.0b	0.0c	0.0a	0.0b	0.0b	0.0a	0.0a	0.0b
Telone II EC (in 100 mm water) +Vapam	0.0c	0.0b	0.0c	0.0b	0.0b	0.0a	0.0b	0.0b	0.0c	0.0a	0.0b	0.0b	0.0a	0.0a	0.0b

Treatment	Merlot/Teleki 5C														
	Meloidogyne sp.			*Criconemella sp.*			*Tylenchulus sp.*			*Xiphinema sp.*			*Paratylenchus sp.*		
	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00
Untreated Control	28.0a	92.8ab	123.6a	1.6b	5.2ab	13.8a	253.6a	314.0a	589.8b	0.0b	24.4a	4.2ab	10.0b	2.0ab	0.6a
18 Month Fallow	17.6ab	97.2ab	91.2ab	4.4ab	2.0b	1.2b	267.2a	394.0a	1096.8a	4.4a	28.8a	4.8a	8.8b	2.0ab	0.0a
18 Month Fallow plus cover crop	1.6b	130.0a	26.4b	8.4a	8.4ab	13.8a	166.0ab	166.0ab	322.2bc	0.0b	2.8b	3.0abc	28.8a	4.0a	0.6a
Methyl Bromide (400 lbs/acre)	0.0c	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	1.2c	0.0a	0.0b	0.0c	0.0b	0.0b	0.0a
Methyl Iodide (400 lbs/acre	)0.0c	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0c	0.0a	0.0b	0.0c	0.0b	0.0b	0.0a

Telone II EC (in 60 mm water) +Vapam	0.0c	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0c	0.0a	0.0b	0.3bc	0.0b	0.0b	0.0a
Telone II EC (in 100 mm water) +Vapam0.0c	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.6c	0.0a	0.0b	0.0c	0.0b	0.0b	0.0a	

Treatment	Merlot/Harmony														
	Meloidogyne sp.			*Criconemella sp.*			*Tylenchulus sp.*			*Xiphinema sp.*			*Paratylenchus sp.*		
	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00	May 99	Oct. 99	Apr 00
Untreated Control	29.2a	19.2ab	25.8a	5.6a	4.4a	2.4a	272.4a	705.0a	1392.0ab	1.6ab	31.2a	7.8ab	18.0a	2.0a	0.0a
18 Month Fallow	2.4b	64.8a	1.2b	3.6ab	1.2ab	2.4a	166.8a	682.0a	2210.4a	0.4b	5.6ab	1.2b	8.4ab	0.0a	0.0a
18 Month Fallow plus cover crop	25.6a	14.4ab	14.4ab	0.8b	1.6ab	1.8a	212.4a	451.0ab	854.4bc	2.8a	8.4ab	10.2a	5.2b	0.0a	0.6a
Methyl Bromide (400 lbs/acre)	0.0c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	0.0b	0.0c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0a
Methyl Iodide (400 lbs/acre)	0.0c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	0.0b	0.0c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0a
Telone II EC (in 60 mm water) +Vapam	0.0c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	0.0b	1.2c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0a
Telone II EC (in 100 mm water) +Vapam	0.0c	0.0b	0.3b	0.0b	0.0b	0.0a	0.0b	0.0b	0.6c	0.0b	0.0b	0.0b	0.0b	0.0a	0.0a